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ABSTRACT

Principles are outlined that are used as a basis for the system of pricing the services of the Computer Centre. The system illustrates the use of a management method to secure better utilization of university resources. Departments decide how to use the appropriations granted to them and establish a system of internal prices that reflect the cost to the university community of the use of its various resources. This decentralized management method requires the university authorities to have rational criteria for determining the appropriations to be allocated to the various departments. The analysis of unit costs is seen as an essential stage in the introduction of a decentralized management method. It should serve as a basis for defining objective standards to be applied to departmental budgetary requirements. User reactions and problem areas are discussed, including planned jobs, time sharing, increase in volume of budgetary appropriations, and surpluses arising from external work. (LBH)

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Programme on Institutional Management
in Higher Education

PRICING THE SERVICES OF THE COMPUTER CENTRE AT THE CATHOLIC UNIVERSITY OF LOUVAIN

by

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and

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Second General Conference of Member Institutions
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Note by the Secretariat

In the context of the co-operative research activities undertaken in the CERI Programme on Institutional Management in Higher Education, a group of seven French universities decided early in 1973 to calculate the economic, global and unit costs of university activities in education, administration, research and the provision of various services. During the same year, two Belgian universities (the Catholic University of Louvain and Liège University) and one Swiss university (Fribourg) decided to participate in the work of this group. They began investigations which, while based on the methodological proposals formulated by the French universities, deviated in some respects since their theoretical options and primary topics of concern were different and their organisational structures were scarcely comparable.

This report, drawn up by Mr. I. Hecquet, Mr. M. Marchand and Mr. J. Jadot of the Catholic University of Louvain, accordingly provides an excellent example of the way in which an internal pricing system, - reflecting the costs involved in the use of various technical facilities (a computer centre in this case), - can lead to a better allocation of university resources and enable the departmental heads themselves to decide how to use the appropriations granted to them. It is clear that the analysis of unit activity costs and the pricing system proposed in this paper are closely related insofar as the first serves as a basis for defining the objective standards required to implement the second.

The Centre for Educational Research and Innovation (CERI) would like to express its most cordial thanks to the authors of this paper.

CHAPTER 1

INTRODUCTION

The purpose of this paper is to set out the principles used as a basis for the system of pricing the services of the Computer Centre, which was introduced in March 1974 at the Catholic University of Louvain, and draw some initial conclusions from the experience acquired. Although the introduction of a system of pricing a computer centre's services is restricted in its aims, it does illustrate the use of a management method to secure better utilization of university resources.

The basic principles of this management method are to leave it to the departments themselves to decide how to use the appropriations granted to them and to establish a system of internal prices which reflect the cost to the university community of the use of its various resources. This decentralised management method does, however, require the university authorities to have rational criteria for determining the appropriations to be allocated to the various departments. The analysis of unit costs, as undertaken by the OECD (CERI), is therefore seen as an essential stage in the introduction of a decentralised management method. It should in fact serve as a basis for defining objective standards to be applied to departmental budgetary requirements.

Before dealing specifically with the system of pricing computer centre services, a rough sketch of the general background to the system will be given in the following chapter. Chapter 3 then sets out the basic principles of the pricing system adopted, while the details of this system and its introduction are given in Chapter 4. Budget allocation and management are described in Chapter 5, while the subsequent chapter draws initial conclusions from the experience acquired and proposes solutions to a number of current problems.

CHAPTER 2

GENERAL BACKGROUND(1)

The management methods currently used in universities usually allocate resources by means of a hybrid system of centralised and decentralised decision-making. As regards some resources, the university authorities reserve the right to decide the quantities to be made available to departments. Teaching and scientific research staff are typical examples where departmental decisions are restricted by an organic framework. In other cases, however, the decision is finally left to departments. Such is usually the case for input costs which are financed through the operating budget and, within the limits of a budgetary allocation, a department can select from among several combinations of these inputs.

Theoretically, a decision-making system completely decentralised at departmental level affords each department a single budgetary allocation to cover all its items of expenditure, whereas a fully centralised system provides individual budgetary appropriations for each input. In the first case, there are no restrictions on the departmental choice of inputs other than to keep expenditure within the budgetary allocation, i.e. the aggregated budget. The second case leaves the department no choice in the combination of the inputs to be used and the quantity of an input available to a department will depend directly on the price of the input and the corresponding amoung of the individual allocation.

Between these two extremes are hybrid systems in which the number of inputs is less than the individual allocations made to the department. In this case a number of categories of expenditure are differentiated (for example, operating, equipment, various categories of staff) and a partial budgetary allocation is made for each of these categories. The smaller the number of partial allocations, the more decentralised the system and, in the extreme case, the departmental budget is aggregated.

These advantages, which are customarily considered to be associated with the decentralisation of decision-making, are sufficiently familiar to make it unnecessary to review them here in detail. The one most commonly quoted is that direct contact with information relevant to their activities makes departments better qualified to select the combination of inputs most suitable for achieving their objectives. In practice, however, it is clear that universities have not pushed decentralisation so far as to aggregate departmental budgets entirely. In particular, university authorities show considerable reserve with regard to expenditure relating to the various types of staff, especially teaching staff.

This reserve may be explained - if not justified - by the recurrent nature of this type of expenditure. Once a teacher is taken on by a department, his remuneration will be a charge on the departmental budget until his retirement. If a department has an over-ambitious recruitment policy when the general situation is favourable (student numbers

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(1) This chapter is primarily based on Marchand (1973).

expanding), its teaching body will be too large when the situation deteriorates (diminishing number of students), and this will hamper recruitment in other departments where the number of staff is inadequate. The authorities are therefore apprehensive that if staff expenditure is included in a global budgetary allocation, some departments may adopt recruitment policies which seriously restrict future recruitment in other departments. The university is in fact itself constrained by a global budget, if not by an individual allocation to cover staff expenditure or an organic structure imposed by the government.

For the above reasons, possibilities of decentralising decision-making by the aggregation of budgets are limited owing to recurrent expenditure. For a thorough analysis, the degree of recurrence of an item of expenditure would have to be ascertained and departmental expenditure classified according to the degree of recurrence. This classification would probably provide a basis for determining the extent to which control of recurrent expenditure should be exercised by the authorities.

The recurrent nature of some expenditure is not the only reason why university authorities have reservations about complete decentralisation of decision-making. Two other reasons may be offered. First, a department's aims may differ from those pursued by the authorities.(1) In this case, the authorities will want to control the use of the departmental budget with a view to imposing a pattern of expenditure consistent with their own aims.

Secondly, decisions taken by certain departments may have (external) effects which promo promote or hinder the aims of other departments. In an entirely decentralised decision-making context, it is doubtful whether departments too would make allowances for this interdependence. This situation is exemplified by library collections, whose purchase by one department may benefit other departments in allied fields. The university authorities may take the view that they alone are in a position to allow for this interdependence in the selection of the resources to be used by departments.(2)

Once the allocation of a resource is decentralised by inclusion of the relevant expenditure in a departmental budget (or in one of its individual allocations), use of this resource has to be accounted for at a specific price, and the means of determining this price will therefore have to be ascertained. There is no difficulty in fixing prices for resources purchased directly on the external market since the market price is entered in the department's accounts. A problem does arise, however, in pricing inputs which are produced by the university's logistical units. The prices of the inputs sold to a department by such units must reflect the cost to the university in producing them. The departmental authorities will accordingly weigh the implications of their decisions in terms of the expenditure they represent for the university.

More specifically, the inputs produced by the university itself should be priced at the marginal cost of production. A practical example will serve to demonstrate the optimum nature of this rule. Let us assume that a research unit has a program that it wishes to improve with a view to reducing the machine time used. This unit must decide how many hours

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(1) The administration itself - which constitutes a pressure group in the university in the same way as the professors and their assistants, etc. also has its own objectives which it may try to carry through.

(2) Marchand (1973, pp. 353-358) proposes a procedure for determining optimum amounts of expenditure on common assets (such as library collections) on the basis of preferences indicated by departments.

a programmer is to work on improving its program. It estimates that a reduction of 6 minutes in machine time will require one hour's work by the programmer, a reduction of 12 minutes, 2½ hours' work by the programmer, etc. On this basis the programmer's time is used with diminishing efficiency since the machine time is reduced by 6 minutes in the first hour but, when the programmer has already been working for 17½ hours, he will have to work a further 6½ hours to reduce the machine time by 6 minutes. Improvements to the programme therefore become increasingly expensive.

If the programmer costs Frs.200 per hour and the computer centre prices the machine-time minute at Frs.100, maximum cost reduction is obtained when the programmer works 2½ hours (see column 3 of the table). If this is the optimum solution for the research unit in question, there is every reason to hope that it would be the same for the university. It will be demonstrated that if the price of machine times does not reflect its marginal cost, this hope cannot be fulfilled. To get a better picture of the situation, let us assume that the marginal cost of machine time is Frs.200 when the price is Frs.100. This is the cost to the university of using an additional minute of machine time. The last column in the table below shows the cost reduction to the university (instead of the research unit in question) according to the number of hours worked by the programmer. The solution adopted by the research unit is clearly not optimal from the standpoint of the university which can obtain a substantial additional cost reduction by making further use of the programmer.

HOURS WORKED BY PROGRAMMER	REDUCTION IN MACHINE TIME	REDUCTION IN COST	
		(Frs.100)	(Frs.200)
1 h.	6 min.	400	1,000
2 h.30	12 min.	700	1,900
6 h.	18 min.	600	2,400
11 h.	24 min.	200	2,600
17 h.30	30 min.		2,500
24 h.	36 min.		2,400

The above example clearly shows that, if the system of pricing at marginal cost is not adopted, prices cannot serve as cost indicators. As the price system does not reflect marginal cost, the costs on which the department bases its decisions differ from those borne by the university.

The corollary of the above arguments in support of the principle of pricing at marginal cost is that any price discrimination in favour of a particular department leads the departments in question to link their possible activities with costs which differ from those assigned by the university to the same activities. Another type of reasoning can also be used to demonstrate that price discrimination does not lead to the optimum allocation of resources. Returning to the practical example quoted above, let us assume that a second research unit has to decide the number of hours to be worked by the programmer to improve one of its programmes and that the first two columns of the table are equally applicable to this unit. Let us also assume that a minute of machine time is priced at Frs.100 for the first unit (as previously) and at Frs.200 for the second unit (whether or not the latter price reflects the marginal cost is of no importance to the rationale that we shall use). The university authorities consider, for example, that the first unit's

budget is inadequate and therefore decide to treat it advantageously by reducing the prices of the inputs that it uses. Where such price discrimination exists, we shall show that the allocation of resources can be improved. The first unit will decide to use 2½ hours of the programmer's time (see third column), whereas the second unit will use 11 hours (see last column) which totals 13½ hours in all. The reductions in machine time are 12 and 24 minutes respectively, i.e. an overall reduction of 36 minutes. The important point is that this overall reduction in machine time could have been achieved if the programmer had worked fewer hours. In fact, it would have been enough for the programmer to have worked 3½ hours longer in the first department and 5 hours less in the second department to obtain a reduction of 18 minutes of machine time for each programme, with the overall reduction in machine time still 36 minutes as previously, although the programmer would have worked 1½ hours less.

Price discrimination leads to inefficient allocation of resources. It was earlier suggested that such discrimination might be attributable to an unsatisfactory allocation of budgets among departments, so the situation can be corrected by redistributing budgets and not by distorting prices.

The principle of pricing at marginal cost has been described and shown to be valid in the preceding paragraphs. As will be seen from the pricing of the computer centre's services, transition from theory to practice in a specific case is far from as simple as the principle suggests. However, pricing at marginal cost has led to many developments of both a theoretical and practical nature in the public services over the last twenty years.(1) Many lessons can be drawn from these developments for the purpose of introducing internal pricing in universities.

The purpose of introducing an internal pricing system may be simply to assign departmental costs on an a posteriori basis, but this is evidently not the view adopted here. This paper seeks to defend the view that internal prices should essentially be used to compare costs entailed by a number of optional courses of action before a decision is taken by a department.

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1) See for example, Boiteux (1949) and Drèze (1964), as regards theory and Lévy-Lambert (1969) for specific applications.

CHAPTER 3

PRINCIPLES TO BE USED AS A BASIS FOR PRICING THE SERVICES OF THE COMPUTER CENTRE(1)

The introduction of a system for pricing its services should enable the Computer Centre to achieve the following major objectives:

i) to inform users of the cost to the university community which running their jobs entails;

ii) to establish a job sequence that takes account of the degree of urgency with which jobs are to be run on the computer;

iii) to facilitate decision-making in respect of the capacity of the Computer Centre's equipment.

1. Cost of running jobs

A system of pricing the Computer Centre's services should enable users to eliminate jobs which cost the community more than they contribute. It should also induce users to programme their work with greater care, at least to the extent that the benefits derived warrant the additional costs. Such results can only be achieved, however, if prices actually reflect the additional costs to the community entailed by running a job.

1.1 Cost of wait time

At first sight, the cost of running a job on a computer would seem to be negligible, so the principle of pricing on the basis of marginal cost should mean that jobs are priced at virtually nothing. This conclusion would be correct if operating costs alone were to be taken into account, but the true picture is more complex. The effect of running a job on a machine is to defer performance of subsequent jobs, thus entailing a wait time cost for which the pricing system must make allowance.

Before the multiprogramming technique was introduced, the additional wait time imposed by one job on the next was simply the period in which the first job was in the machine, so the price to be charged for running a job had to be proportional to this period. Modern computers, using the multiprogramming technique, now handle several jobs at the same time. The time taken to complete a job depends on the workload imposed upon the various facilities involved in running it (central processing unit, main memory, input-output channels, etc.) and, accordingly, it depends on the use made of these various facilities by the jobs sharing the machine. The period required to complete a job therefore becomes a random variable, as the characteristics of machine use by other jobs cannot in fact be foreseen. Since it is inconceivable that the price of a job should vary in relation to circumstances over which the user has no control, the price has to be fixed on the basis of the average workload imposed upon the system's different facilities at the time the work is done.

The first stage in calculating the price of a job consists of determining the number of "computation-units" consumed in performing it. According to the above principles, the

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1) Many publications have dealt with the problems of pricing the services of computer centres: see Nielsen (1970) and the bibliography given in this paper.

parameters of the formula for calculating this consumption should vary in proportion to the average delay that completion of the job imposes on subsequent jobs. The consumption of computation-units, corresponding to the use of each unit of the facilities in the system, should therefore reflect the average scarcity of the facilities in question.

The use made of the different facilities varies systematically according to whether the work is performed during the day or night. Jobs performed at peak hours normally make greater use of input-output channels than those performed during slack periods. On average, therefore, changes in the workload imposed upon the system's different facilities can be foreseen (input-output channels are more congested during the day than during the night) and this must be taken into account in the pricing system. More specifically, the number of computation-units consumed by an input-output operation should be higher during the day than during the night, while the reverse should be the case in the utilisation of the central processing unit. Users should therefore be encouraged to have I/O bound jobs run at night, i.e. jobs calling for only moderate use of the central processing unit and substantial use of input-output channels. The reverse will be true for CPU bound jobs. We shall return to this point later.

As the workload imposed upon the computer's different facilities can change with an increase in demand or modifications to the characteristics of demand, it must be possible to make regular adjustments (every three months, for example) in order to increase or reduce the number of computation-units corresponding to the use of certain facilities for which the workload has shown a significant rise or fall. It should be pointed out here that the user can to some extent modify the combination of the system's facilities used to run his programmes. Thus, as a result of greater workload imposed upon the main memory, the number of a programme's input-output operations may be reduced. If the pattern of demand leads to a bottleneck in the input-output channels, the number of computation-units consumed by an input-output operation should be increased to reflect the increased cost of wait time arising from the use of the input-output channels, and accordingly induce users to alter the combination of facilities used for their jobs.

1.2 Priority and cost of wait time

As the cost of wait time imposed on subsequent jobs in line is higher for a top-priority job than for a low-priority job owing to the fact that more jobs are delayed, it is reasonable to gear the increase in the job's price to its level of priority. This can be achieved in practice by pricing the computation-unit on a scale rising with the level of priority.

Hourly variations in the workload imposed upon the sytem's different facilities have already been mentioned. As most high-priority jobs are run during the day and most low-priority jobs during the night, price differentials for the various times can initially be roughly established by varying the number of computation-units consumed in the utilisation of the different facilities according to the priority given to the job.

1.3 Operating and capital costs

In addition to the wait costs which performance of a job imposes on other users, each job also entails an increase in some of the Computer Centre's other costs, such as the cost of operators, punch cards, paper, etc., which are all to be included under the heading: variable costs of the Computer Centre, and their total will depend on the extent to which the Centre is used. They are to be distinguished from fixed costs, which are attributable to the hire or purchase of equipment, remuneration of the staff of the "system" group,etc. Fixed costs do not vary according to the extent to which the Computer Centre is used and they absorb the bulk of its budget. The total fixed and variable costs are the Computer Centre's operating and capital costs. As the performance of a job does not affect the

amount of fixed costs, they should not be taken directly into account in the pricing system. Pricing policy should in fact achieve the short-term aim of controlling the utilisation of facilities so as to derive the maximum benefit from existing equipment. As we shall show in due course, the price level which makes this a feasible short-term aim should also serve as the necessary indicator for a long-term investment policy.

As will be explained later in this paper, the computer's capacity should be such that the Computer Centre has a balanced budget with its variable and fixed costs covered by prices. It must be emphasised at the outset, however, that the Computer Centre should be authorised to end some financial years with a budgetary deficit which would be offset by surpluses in other years.

It may be concluded from the foregoing that the pricing system adopted should consist of two sections: (i) a relatively minor section covering variable costs and independent of the level of priority; and (ii) a section varying with the level of priority (which will cover the Computer Centre's fixed costs in the long-term).

This pricing system relates to the Computer Centre's facilities that are shared by all users. Other facilities such as disk storage units (or part of disk storage), magnetic tapes, terminals etc. are reserved for the exlusive use of individual users and their pricing entails fewer problems, since the price for using them should be such as to cover the cost of hiring or purchasing them.

2. Allocation of priorities according to urgency

With a view to achieving the second objective listed above (allocation of priorities according to the degree of urgency), the choice of the level of priority should be left to the user, who will make his decision according to the urgency of his work.(1)

In order to make an informed choice, however, the user must have an approximate idea of the wait time involved in submitting his work at each level of priority. As user demand is characterised to a large extent by random factors, waiting periods can change unforseeably from one hour to the next. However, on the basis of jobs waiting in line under the various priorities, the Computer Centre should be able to inform users of the wait times that must be expected at each level of priority and update this information regularly (for example, every hour) if not continuously. This information, which some university computer centres show on a cathode screen, can only be given as estimated wait time, but acquired experience of user behaviour should gradually make it possible to obtain more accurate estimates.

In the proposed pricing system it should be noted that, aside from the adjustments referred to in the previous section, the price allocated to a level of priority does not vary over time. However, these adjustments concern only the relative values of the parameters in the pricing formula. The price level allocated to a level of priority therefore remains constant. On the other hand, the wait time attached to a level of priority will vary from hour to hour and according to the day of the week. Furthermore, as demand for computer services will, in all likelihood, continue to expand in future, the workload imposed upon a computer will increase continuously from the time it comes into service, thus entailing longer wait times for each level of priority. If a user wishes to keep the wait time for his jobs approximately the same, he will have to choose increasingly high priorities and correspondingly higher prices as the machine becomes saturated. In the system advocated, the price to be paid to ensure a constant quality of service will therefore vary in direct relation to the workload imposed upon the computer.

On the plausible assumption that demand will continue to expand, the price (for a constant quality of service) will be relatively low in the months following the introduction of a more powerful machine (at which time there will be surplus capacity), but the price will rise as demand absorbs machine capacity. This "zigzag" trend in prices (at

1) See Marchand (1974) for the theoretical discussion of this point.

constant quality of service) could be attenuated by selling computer time on the external market during periods in which capacity exceeds the requirements of the university community.

3. Investment planning

The third objective (to facilitate decision-making as regards investment) can be achieved by requesting the Computer Centre to balance its budget on a multi-annual basis, i.e. more specifically over a period ranging from the time the computer comes into service to the time it becomes obsolete. In the pricing system described above, this requirement should dictate the Computer Centre's investment policy, at any rate as regards the capacity of future equipment. If the equipment is too powerful, the Centre's multi-annual budget will show a deficit.

The pricing principles set out above are incompatible with a system whereby the Computer Centre would be required to cover its fixed and variable costs from the income earned in each budgetary year. As demand for computer services increases over time, this requirement would entail a high price in the years immediately following the installation of new equipment and a low price in the years before it became obsolete.(1) Over the initial years, in fact, the fixed costs of the computer should be spread over a smaller volume of production than during the final years. Insistence on an annually balanced budget would therefore serve to discourage the use of the computer by high prices when it has ample facilities and very small workload and encourage its use by low prices when it has few facilities and a big workload. Such a requirement would run counter to the basic economic principle that the price of a resource should be a direct function of its scarcity. In the pricing system advocated, the Computer Centre's deficit during the surplus capacity phase should be offset by its credit balance during the period when the machine is fully utilised. The reason for insisting on a balanced budget is to provide the necessary incentive for efficient internal management of the Computer Centre (to maximise production and quality of service on the basis of the resources provided). It is in fact generally considered that a satisfactory method of internal management can only be ensured if those responsible for the Computer Centre are obliged to keep to a balanced budget, which means that the existence of a permanent deficit is unacceptable from a policy standpoint. However, it should be noted that, since computers show increasing returns to scale, insistence on a balanced budget is incompatible with the aim to achieve efficient allocation of resources (particularly the effort to ensure that resources are correctly distributed between the Computer Centre and the University's other activities). This viewpoint will be further examined and justified in Chapter 5 when we consider how surpluses on outside contracts are to be allocated. Two conflicting aims are involved: insistence on a balanced budget stresses the need to establish satisfactory internal management.

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1) In this connection, see Kanter et al. (1966).

CHAPTER 4

INTRODUCTION OF THE PRICING SYSTEM

Before the introduction of pricing, priorities were assigned to work according to the use made of certain facilities (CPU time, memory space and number of printed lines). The user entered the characteristics on a control card and the computer automatically determined the order of priority of the work: the less use made of the various facilities, the higher the priority assigned to the job. This procedure meant that jobs were handled in more or less run-time order with the shortest jobs receiving the highest priority. This system of assigning priorities was quite reasonable when no information whatsoever was available on the degree of urgency with which users wished to have their jobs completed, in which case they could in fact only be assumed to have the same urgency. Given certain assumptions, it can be shown that this method of assigning priorities minimised the overall wait cost if the jobs had the same degrees of urgency. This system of management likewise maximised the number of jobs run during the day. On the other hand, when jobs show didfferent degrees of urgency, it is no longer the optimum principle to carry out the jobs in run-time order, and priorities can no longer be assigned solely on the basis of the run-time.

Two proposals were put forward in the discussions preceding the introduction of the system of pricing the Computer Centre's services. One was based on the principles set out in Chapter 3 and the other on the concept of "normal price", whereby users selecting the same level of priority as was previously assigned to them, would have been charged on the basis of the "normal price": the price by "computation-unit" was independent of the priority. On the other hand, jobs for which the priority selected was higher (or lower) than that previously assigned would have been priced on the basis of a "computation-unit" price higher (or lower) than the normal price. This proposal was consistent with the aim to maximise the number of jobs run during the day since the concept of the normal price would have induced users to select the same priority as that assigned to them previously.

However, the second proposal was not consistent with the principle of pricing on the basis of marginal cost, and two users consuming the same number of computation-units with different priorities would have spent the same amount in computation-francs, although the user adopting the highest priority would have imposed higher wait costs.

The pricing system finally adopted conforms to the principles set out in Chapter 3. The number of computation-units consumed by a step (a component part of a job) is determined by means of the formula set out in Annex 1.

The number of computation units consumed by a job - as calculated according to this formula - should be proportional to the additional average wait time that the job imposes on each job following it on the machine. For reasons attributable to the fact that the UCL shares its computer (IBM 370-155, subsequently 158) with the KUL and a private company, it has not been possible to adopt parameters for this formula which have numerical values differing from those used to show the consumption of the three partners in the co-operative. A thorough statistical study should make it possible to determine the values of the parameters of this formula in accordance with the principles outlined in Chapter 3. The analytical aspect of the formula is probably satisfactory.

Based on maximum estimates given by the user on his job card, the following table shows the category to be assigned to his work.

Table 1: Definition of categories

	USER ESTIMATES		
CATEGORY	CPU t	REGION R	NUMBER OF LINES L
1	t<1'	R<270K	L<10.000
2	1'<t<4'	R<270K	L<100.000
3	4'<t<15'	R<270K	L<100.000
4	t>15'	R>270K	L<100.000

The computation-unit price for each category and each priority are shown in the table below:

Table 2: Computation-unit price

PRIORITY	Categories			
	1	2	3	4
7	0.60	0.60	NA	NA
6	0.50	0.50	0.50	NA
5	0.40	0.40	0.40	0.40
4	0.30	0.30	0.30	0.30
3	NA	0.20	0.20	0.20
2	NA	NA	0.10	0.10

The initials NA indicate that the corresponding priority cannot be requested for jobs in the category shown. These restrictions will subsequently be removed on the basis of experience acquired. They were introduced to preclude any possibility that the user's choice of priority should entail substantial changes in the allocation of jobs among the priorities in the transitional phase and thus lead to corresponding delays. The aim was to keep the experiment under control and avoid disorganisation at the Computer Centre.

Two problems arose in connection with the numerical values shown in the price table. On the one hand, the average price level had to be adopted, and this was calculated, on the basis of previous consumption, so that the operating costs of the Computer Centre balanced its income. Furthermore, price differentials between successive priorities had to be determined. Two considerations were involved. First, users had to allocate their jobs among the various priorities so that the wait times differed significantly from one priority to the next (in other words, a sufficiently wide range of qualities of service was offered to users). Had the differentials been too narrow, users might have concentrated their choice on the highest levels of priority. Secondly in view of the way in which the budgets in computation-francs are allocated among users (see following Chapter), it was necessary to avoid eliminating all choice owing to unduly wide differentials. Aside from these two considerations, which are moreover conflicting, the differentials were determined on a largely arbitrary basis.

In addition to the invoicing of work performed on the computer, the use of certain services (such as WATFIV, teleprocessing, service bureau programming) and magnetic media are subject to special pricing which will not be dealt with in detail here.(1)

The information on wait times currently available to users is primarily derived from a monthly record of wait times (averages and percentiles according to the time of day and level of priority requested), an example of which is given in Annex 2. A list of jobs in line (number of jobs at each level of priority) is also available and updated every two hours, thus enabling users to estimate delays at the various levels of priority on a more accurate basis than the monthly records. To make such estimates, however, users require sound experience which cannot be acquired by more or less casual users. The ideal solution would be to develop a procedure whereby the system itself estimated, at regular intervals, the wait time at each level of priority on the basis of the list of jobs in line.

1) Supplementary details can be found in the special number of UCL Information (February 1974) devoted to the system of pricing the Computer Centre's services.

CHAPTER 5

BUDGET ALLOCATION AND MANAGEMENT

The budgets allocated to units(1) for the transitional period running from 15th March to 31st December, 1974, were based on consumption in the preceding year. These budgets were calculated on the equal advantage principle, i.e. the budget allocated to a unit was designed to enable it to maintain the levels of priority imposed prior to the introduction of the pricing system and accordingly ensure the same quality of service. This budget was the result of adding together the computation-units consumed during the preceding year, weighted by the (computation-unit) prices shown in Table 2 of the previous chapter.

During the transitional phase, faculties were allocated a budget in computation-francs equivalent to 10 per cent of the overall budget for their units. This budget constituted a reserve to enable the faculty to finance new activities calling for computer services.

The units are responsible for allocating the budget received to the users dependent on them and, where possible, they build up reserves. If a user wishes to avail himself of the Computer Centre's services, his user's number must correspond to a budget which shows a credit balance in computation-francs. The costs relating to a job are automatically invoiced as it is being run and the user is immediately notified of the number of computation francs consumed in respect of his job, the various facilities used in the system and the budgetary balance remaining under his user's number.

The authorities responsible for the unit are provided with monthly data on the budgetary situation of the users dependent on their unit. Deans of Faculties are given similar information on the budgets for their units. These monthly records - examples of which are given in Annex 3 - include, inter alia, two particularly important items of information, namely the level of consumption and the average cost of the computation-units consumed.

The level of consumption by a user (shown in the record sent to those responsible for his unit) or by a unit (shown in the record sent to the dean of the relevant faculty) is calculated as follows:

$$\text{Level of consumption: } \frac{B}{12} N - C$$

where B = annual budget allocated to the user or unit (computation-francs)

N = number of months which have elapsed since the beginning of the current budgetary period

C = overall consumption over past months.

It can be concluded from a negative level of consumption that the budget of the user or unit has been overdrawn (in relation to a consumption equally spread over the months of the current budgetary period).

The average cost of computation-units consumed by a user or unit is calculated by dividing the consumption in computation-francs by the consumption in computation-units.

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1) Terms used at UCL to designate a research or teaching department.

This information makes it possible to estimate the average level of priority requested by the user or unit and it is essential to any control or decisions by unit authorities and deans of faculties.(1) In this connection it should be noted that access to priorities lower than five may be barred to certain categories of user by unit authorities. A control system is used to check whether these restrictions are respected.

During the current experimental period, it has been necessary to allocate budgets in non-transferable computation-francs. As the community's needs in terms of computer services are not clearly defined at present, precautions have had to be taken against the risk that the Computer Centre (and therefore the university) might run a deficit. In the long-term, however, expenditure on computer services should be financed directly from the operating budgets of faculties, institutes and units which will themselves decide how much of their budget is to be allocated to the Computer Centre's services.

The long-term charging of expenditure on computer services to operating budgets fulfils a dual need. First, as explained in Chapter 3, it is the only way of obtaining pertinent information on how equipment is geared to the community's needs with respect to computer services. Indeed, it should be noted that, in a system where budgetary allocations for computer services cannot be transferred to other items of expenditure, the total income of the Computer Centre is no more than the overall total of the budgetary appropriations which have been allocated to faculties and units for computer services. Secondly, the allocation of budgetary appropriations for expenditure on computer services raises the problem of defining objective allocation criteria and ensuring compatibility with other budgets. It would also call for the introduction of an expensive budgetary procedure (supplementing the budgetary procedures already existing). It therefore seems advisable to allocate an overall operating budget to units and leave it to them to decide what proportion of this budget is to be allocated to the Computer Centre's services. This approach is consistent with the principles advocated in Chapter 2 which dealt with the decentralisation of decision-mak by the aggregation of budgets.

The charging of expenditure on computer services to operating budgets is a long-term objective. Budgetary appropriations for computer services should gradually be made transferrable by increasing the proportion of such appropriations which can be used to cover other expenditure.

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1) Further details on budgetary procedures and budget management are provided in the special number of UCL Information (February 1974) devoted to the system of pricing the Computer Centre's services.

CHAPTER 6

USER REACTIONS AND AN EXAMINATION OF SEVERAL PROBLEMS

Considering the novelty of the pricing system, users adjusted to it relatively quickly. The main problem arising in the early days of its introduction concerned the accumulation of jobs under priority 5, i.e. the priority assigned when the user indicated no other level on his control card. It was, moreover, the highest priority that could be obtained by certain categories of user. More than 50 per cent of jobs were accordingly performed at the level of priority 5 in the fortnight following the introduction of pricing. This percentage has since dropped steadily to 34 and 26 per cent in July and August respectively, thus showing that users have gradually become accustomed to selecting their level of priority (see Table 3).

Pricing induced users to select lower average levels of priority than had previously been assigned to them. The average "computation-unit" price dropped in the months following its introduction and the proportion of jobs run at the lowest priority rose from about 1 per cent to over 10 per cent.

No final conclusions about user reactions can be drawn at present however, owing to the newness of the system and the seasonal nature of demand (in particular, note the trend of monthly consumption in computation-units).

Having briefly reviewed user reactions to the introduction of pricing, we shall devote the rest of this chapter to the examination of several problems experienced by the Computer Centre's Board of Management under the existing system.

A. Planned jobs

The way in which the selected pricing system has been devised satisfies the needs of users in scientific fields who are rarely able to plan their requirements in advance and are therefore prepared to accept some uncertainty as to the quality of service in return. It may therefore be asked whether this system does not place some users at a disadvantage, especially the university's administrative departments which would be prepared to submit to strict planning of their work in return for guaranteed run times. This argument involves the fairness of the system adopted. Had the system been devised with a view to the requirements of users who could plan their jobs, the Computer Centre would in fact have been able to guarantee run times. As the choice of the system deliberately benefits one type of user to the detriment of another, a solution should be found whereby users ready to accept strict planning of their work enjoy the same conditions that would have prevailed if a system had been adopted to satisfy their requirements. Such a solution could be based on the following principles: the guaranteed run time requested by the user would be granted at a rate based on the average prices of priorities that have to be selected to meet the deadline specified. Let us suppose, for example, that the administrative departments plan to submit a routine job at 10 a.m. Tuesday morning and request a guaranteed run time of 2 hours. Probabilities have to be established for each priority and can be determined on the basis of the statistical data on wait times for jobs submitted at 10 a.m. on Tuesday which

Table 3

Assignment of jobs run between 9 a.m. and 12 noon	January	February	March (15th to 31st)	April	May	June	July	August
Priority 7	27,2	28,8	25,1			25,7	27,8	31,8
6	38,8	38,6	9,2			11,3	9,1	14,9
5	3,3	4,0	52,2			36,3	33,9	26,2
4	19,4	18,0	4,0			6,9	5,3	7,3
3	10,3	10,2	4,7			7,5	10,1	7,7
2	1,0	0,4	4,8			12,3	13,8	12,2
Average wait time(a) for jobs between 9 a.m. and 12 noon								
Priority 7			22'	14'	10'	15'	21'	29'
6			30'	18'	22'	33'	38'	1h46'
5			1h24'			1h57'	1h41'	2h35'
4			6h04'	4h37'		5h38'	5h47'	3h37'
3			7h27'	5h19'		6h18'	7h52'	6h21'
2			9h02'	6h59'	10h38'	9h14'	8h35'	8h16'
Average "computation-unit" price	0,31	0,35	0,33	0,27	0,27	0,29	0,27	0,30
Number of computation-units consumed (in millions)	18.128	18.892		15.516	18.809	10.904	14.271	11.660

(a) This is the time elapsing between reading the control card and the end of printing out results. Aproximately half an hour must also be allowed for entering and leaving the machine room.

are kept up to date by the Computer Centre. The average price can be determined on the basis of these probabilities. This solution would satisfy the need for fairness while maintaining the principle of pricing at marginal cost. It would require that the "planned job" be defined accurately to avoid misrepresentation and that the sequence of running jobs should be supervised to ensure that the guarantees of run times are in fact fulfilled.(1)

B. Time sharing

The same type of solution can be proposed for pricing the time-sharing service which was not in use when the system was introduced. This service calls for absolute priority over all jobs in hand, and it was therefore logical that it should be priced on the basis of the price of the (lowest) priority which guaranteed that it would be run before the jobs in hand. If the aim is to introduce a system of pricing time-sharing services which does not fluctuate randomly according to the volume of work in hand,(2) the average price of the above-mentioned priority can be determined according to the hour at which the connection is made (on the basis of statistical data which can be collected).

C. Increase in volume of budgetary appropriations

After allocation of the budgets determined according to the principles set out in the preceding chapter, supplementary appropriations were granted to the administration and to certain faculties. Under a system whereby transfers are not allowed, supplementary appropriations will give rise to price inflation (the waiting time will increase for a given level of priority and therefore for a specific price; in other words, a higher price will have to be paid for a given wait time:(3) jobs will tend to be assigned to higher levels of priority. Such a trend may lead to pressure on the highest priority available if a sufficient number of higher levels of priority are not provided (with a consequent reduction in the choice available to users with respect to wait times). More generally speaking, it may be said that if the price range is sufficiently wide and no restrictions are imposed on the choice of priorities, the doubling of computer-service budgets allocated to units (in a system in which transfers are not allowed) will finally lead to the doubling of prices for each quality of service provided.

D. Surpluses arising from external work

During slack periods (see Chapter 3), the Computer Centre offers its surplus capacity on the data processing market. Aside from the effect of such external work on the wait times imposed on internal users (it is necessary to have strict rules concerning periods during which external jobs may be performed), a decision has to be taken concerning the use to be made of the surplus arising from the difference between internal and external prices. This surplus can be used in two ways: it can be incorporated in either the Computer Centre's

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1) As a means of solving this problem of fairness, consideration has been given to dividing the computer into what would be - to all intents and purposes - several machines which could be run individually. However, the management of such a system would entail the use of a substantial proportion of the computer's facilities which could not then be used productively in running jobs.

2) In an identical context, Vickrey (1971) advocated a pricing system whereby the user, before deciding to establish the connection, consults the computer to obtain the operative price, i.e. the price of the (lowest) priority guaranteeing precedence over the jobs in hand. As the operative price will fluctuate in the course of the connection, the information will have to relate to the estimated average price during the connection.

3) This will also entail a redistribution of real budgets (as opposed to nominal budgets) to the detriment of faculties whose appropriations have not been increased.

income (to help balance the Centre's budget) or the university's operating budget. In a system allowing transfers, the first solution would enable university users of the Centre to obtain services of a given quality at lower prices. As the two possibilities have the same final effect on the university's operating budget in a system allowing transfers, the choice between the two must be based on the effective allocation of university resources. More specifically, is it desirable to obtain the price reduction and increased data-processing resources resulting from the first use? This question can be answered in the affirmative on the basis of the principle of pricing at marginal cost. Without going into detail, the argument can essentially be summarised as follows:

The computer shows increasing returns to scale, i.e. for a constant level of quality, the value of services provided increases at a faster rate than the cost of the equipment. When production of a unit of goods or services shows increasing returns of scale, the marginal cost of production is lower than the average cost. Consequently, income obtained through pricing at marginal cost will not cover production costs. In the case of increasing returns of scale, therefore, the optimum allocation of resources will not be achieved if a balanced budget is called for.

If the capacity of the Computer Centre's equipment is stepped up, it can increase the volume of services provided at each quality level. The monetary value that users attribute to these additional services can be determined by applying the corresponding prices to them. The capacity should be increased when the cost of doing so is less than the value of the additional services made available. The optimum situation occurs when the cost of an increase in capacity is the same as the value of the additional services. However, the Computer Centre does not have a balanced budget as the marginal cost of capacity is less than the average cost.

As the Computer Centre is required to balance its budget (on a multi-annual basis), the prices are too high and the installed capacity is smaller than it should be. The level of prices is in fact based on the average cost of installed capacity rather than on its marginal cost (which is lower than the average cost owing to increasing returns of scale). This inefficiency can be partly offset if the surpluses obtained on external contracts are included in the Computer Centre's income, thus enabling prices conforming to the budgetary constraint to be brought more into line with what they should be if based on the marginal cost of installed capacity.

The foregoing argument applies to the case in which budgets for computer services have been made transferable to other items of expenditure. Where such transfers are not allowed, it is not the Computer Centre's responsibility to determine the capacity to be installed. In this case, the level of prices does not in fact provide the Centre with any indication of the community's real requirements, thus preventing any decentralisation of decision-making with respect to the capacity of equipment. It is up to the university authorities to take this decision. In this case, therefore, surpluses obtained on external contracts should not be left under the Computer Centre's authority.

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ANNEX I

FORMULA FOR MEASURING THE NUMBER OF COMPUTATION-UNITS CONSUMED BY A STEP

$$UNITS = 66.349 + 9.533\ CPU + 0.126\ EXCP + 1.222\ (10.5 + PSET)\left(0.25 + \frac{REG + 0.2\ (REG)^2}{1.2}\right) + 0.212\ (CAREAD + LINES) + 0.556\ CAPUNCH + 0.201\ PSET\ (DVOL + TVOL) + 275\ SETUPS$$

CPU = period of utilisation by step of the central processing unit (in seconds)

UNITS = number of computation-units consumed.

EXCP = number of input/output operations during execution of the step (execute channel programme)

REG = size of memory required for the step, expressed in K and divided by 100 (region requested)

PSET = CPU + 0.025 IOR
= estimate of the time used for the step by the initiator-terminator (in seconds) (pseudo elapsed time)

CAREAD = number of cards read (card reading)

LINES = number of lines printed

CAPUNCH = number of cards punched (card punching)

$$IOR = EXCP + \frac{CAREAD + CAPUNCH + LINES}{10}$$ (input-output record)

DVOL = number of disks used by the step (disk volume)

TVOL = number of magnetic tapes used by the step (tape volume)

SETUPS = number of disks, magnetic tapes and special forms set up.

	INFORMATION CODE/PAGE	NO.	DATE	AUTHOR(S)	NATURE	For any enquiry contact
A4		169	5.11.74	P. DE COCQ	Service wait time at the Computer Centre	Service Bureau

Annex 2

WAIT TIMES FOR SERVICES AT THE COMPUTER CENTRE

PERIOD FROM 23/9/74 TO 31/10/74

WAIT TIME BETWEEN *READER TIME* AND *END EXECUTION

74.308 12.45.14 PERIOD FROM 23/09/74....00H.46M.00S TO 31/10/74....06H.50M.00S

HOUR	0/0	CLASS -7- WTIME	NU	CLASS -6- WTIME	NU	CLASS -5- WTIME	NU	CLASS -4- WTIME	NU	CLASS -3- WTIME	NU	CLASS -2- WTIME	NU
1- 3	50	.00H.06M	4										
	70	.00H.12M	5									.00H.10M	1
	80	.00H.13M	6										
	95	.00H.30M	7									.00H.11M	2
	MEAN	.00H.10M	7									.00H.11M	2
3- 6	50									.00H.04M	3	.00H.22M	3
	70									.00H.04M	4		
	80	.00H.00M	2							.00H.04M	5	.00H.39M	4
	95	.00H.05M	3					.00H.00M	1	.00H.23M	6	.00H.41M	5
	MEAN	.00H.02M	3					.00H.00M	1	.00H.07M	6	.00H.22M	5
6- 9	50	.00H.05M	28	.00H.04M	7	.00H.08M	24	.00H.04M	15	.00H.16M	20	.00H.14M	7
	70	.00H.12M	39	.00H.07M	10	.00H.23M	34	.01H.25M	20	.01H.45M	27	.00H.21M	10
	80	.00H.13M	45	.00H.13M	11	.00H.28M	38	.01H.27M	23	.02H.04M	31	.00H.42M	11
	95	.00H.37M	53	.00H.33M	13	.02H.06M	46	.13H.00M	28	.23H.09M	37	.01H.08M	13
	MEAN	.00H.10M	56	.00H.09M	14	.00H.35M	48	.03H.20M	29	.08H.31M	39	.01H.25M	14
9-12	50	.00H.12M	401	.00H.12M	86	.00H.35M	270	.02H.42M	90	.07H.06M	84	.10H.02M	139
	70	.00H.23M	561	.00H.44M	120	.01H.53M	378	.08H.13M	126	.09H.33M	117	.11H.42M	154
	80	.00H.34M	642	.01H.42M	138	.03H.25M	442	.08H.52M	144	.11H.36M	134	.12H.48M	222
	95	.01H.36M	762	.07H.37M	163	.08H.14M	513	.11H.55M	171	.14H.55M	159	.14H.50M	263
	MEAN	.00H.26M	802	.01H.20M	172	.01H.51M	540	.04H.25M	180	.06H.39M	167	.07H.33M	277
12-15	50	.00H.11M	286	.00H.18M	56	.00H.35M	197	.03H.30M	59	.05H.21M	73	.09H.54M	96
	70	.00H.21M	400	.00H.50M	78	.02H.13M	275	.04H.58M	83	.06H.44M	102	.10H.59M	134
	80	.00H.31M	457	.01H.20M	90	.04H.00M	314	.05H.34M	94	.07H.32M	116	.11H.30M	154
	95	.01H.48M	542	.04H.11M	106	.06H.04M	373	.06H.59M	112	.08H.43M	138	.12H.15M	182
	MEAN	.00H.26M	571	.01H.02M	112	.02H.01M	393	.03H.08M	118	.04H.42M	145	.08H.49M	192
15-18	50	.00H.12M	421	.00H.25M	87	.01H.01M	314	.03H.20M	145	.05H.02M	221	.08H.09M	246
	70	.00H.25M	589	.01H.07M	93	.02H.00M	440	.04H.09M	203	.05H.48M	309	.09H.01M	344
	80	.00H.45M	673	.01H.41M	106	.02H.44M	502	.04H.36M	232	.06H.16M	353	.09H.30M	393
	95	.01H.30M	749	.03H.10M	126	.04H.37M	597	.06H.42M	276	.07H.56M	419	.10H.54M	466
	MEAN	.00H.31M	841	.01H.03M	133	.01H.30M	628	.03H.11M	290	.04H.43M	441	.07H.46M	491
18-21	50	.00H.05M	88	.00H.09M	7	.00H.12M	168	.00H.58M	53	.02H.40M	79	.06H.38M	106
	70	.00H.10M	123	.00H.28M	10	.00H.28M	235	.01H.52M	74	.03H.37M	111	.07H.15M	148
	80	.00H.15M	140	.00H.30M	11	.00H.50M	269	.03H.16M	84	.04H.25M	126	.08H.04M	169
	95	.00H.33M	166	.00H.45M	13	.01H.45M	319	.04H.39M	100	.05H.42M	150	.09H.01M	200
	MEAN	.00H.11M	175	.00H.19M	14	.00H.28M	336	.01H.34M	105	.02H.57M	158	.06H.34M	211
21-24	50	.00H.08M	28			.00H.16M	33	.00H.08M	8	.01H.32M	11	.04H.51M	14
	70	.00H.14M	39	.00H.12M	1	.00H.28M	46	.00H.13M	11	.01H.54M	15	.05H.51M	20
	80	.00H.21M	44			.00H.37M	53	.00H.25M	13	.02H.27M	17	.05H.24M	22
	95	.01H.14M	52	.00H.15M	2	.01H.54M	63	.00H.26M	15	.03H.27M	20	.06H.52M	27
	MEAN	.00H.18M	55	.00H.13M	2	.00H.36M	66	.00H.14M	16	.01H.27M	21	.04H.47M	28

WTIME - period elapsing between the time that the job control card is read and the time at which the printout of results is completed. About 30 minutes should be added for access to the computer-room and exit.

NU - number of jobs performed.

Distribution : 1, 11.

CENTRE DE CALCUL UCL

3030 HEVERLEE — 52, de Croylaan Tél. 016/349.31

1348 LOUVAIN-LA-NEUVE — 3, Place du Levant Tél. 010/472.53

DATE 14/08/01 TIME 09/03/12

UCL - MONTHLY RECORD OF USE OF THE COMPUTER

REFERENCE PERIOD: 28/06/74 TO 31/07/74
GROUP: RECI UNIT: SEI

Annex 3

JADOT
SERVICE D'ETUDE
KRAKENSTRAAT 3
3000 LEUVEN

(1) BUDGET NUMBER
(2) RESPONSIBLE AUTHORITY
(3) BUDGETARY APPROPRIATIONS ALLOCATED
(4) EXTERNAL FINANCE
(5) ADDITIONAL BUDGETARY APPROPRIATIONS
(6) BUDGETARY APPROPRIATIONS DISTRIBUTED
(7) COMPUTATION-FRANCS USED EACH MONTH
(8) ADDITIONAL COMPUTATION-FRANCS
(9) TOTAL BUDGETARY APPROPRIATIONS USED (PREV.9 + 7 + 8)
(10) STRD-UNITS USED EACH MONTH
(11) TOTAL STRD-UNITS (PREV.11 + 10)
(12) COEFFICIENT OF CONSUMPTION
(13) LEVEL OF CONSUMPTION

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
U04242A	INGHELS FR.	130000				20802	884	81710	49025	205024	42	-20150
U04148A	BEGUIN A.	13877				1220	1	9991	6102	52094	19	-3421
	TOTAL:	143877				22022	885	91701	55127	257118	39	-23571
	TOTAL (12 MONTHS):					264264	10620		661524			
	RECAPITULATIVE	143877			143877	22022	885	91701			39	-23571
	BALANCE (3) + (4) - (6)	0										
	BALANCE (6) + (4) - (9)	52176										

22 26

DATE 0 74/06/28 TIME 0 17/27/53

UCL - MONTHLY RECORD OF USE OF THE COMPUTER

REFERENCE PERIOD 0 05/06/74 TO 28/06/74

GROUP 0 UNIT 0

MR. DE BRUYNE
FACULTE DES SCIENCES ECONOMIQUES
DEKENSTRAAT 2
3000 LEUVEN

(1) BUDGET NUMBER
(2) RESPONSIBLE AUTHORITY
(3) BUDGETARY APPROPRIATIONS ALLOCATED
(4) EXTERNAL FINANCE
(5) ADDITIONAL BUDGETARY APPROPRIATIONS
(6) BUDGETARY APPROPRIATIONS DISTRIBUTED
(7) COMPUTATION-FRANCS USED EACH MONTH
(8) ADDITIONAL COMPUTATION-FRANCS
(9) TOTAL BUDGETARY APPROPRIATIONS USED (PREV9 + 7 + 8)
(10) STRD-UNITS USED EACH MONTH
(11) TOTAL STRD-UNITS (PREV11 + 10)
(12) COEFFICIENT OF CONSUMPTION
(13) LEVEL OF CONSUMPTION

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
	P.DEBRUYNE	173108			60000	18689	3979	46917	72621	128153	25	16853
ACTU	REUMTER	54739			20402		50	5338		30937		10822
ANEC	L.PHILIPS	1241593			618476	123048	57772	592503	877260	2885361	14	-135088
BASS	BONNARIAGE J.	2457211	105188		1220368	206805	14221	956108	495212	2886467	41	-12088
CACS	VERCAUTEREN	10000			10000							3675
COMU	BERTEN	5000			5000							1820
CSAM	J.J.LAMBIN	272359		15000	272359	26905	20	97264	60262	265755	44	3046
CSUR	REMY J.	27142			10000			492		2470		9483
DEMO	M.MOITRIN ET G.HUNS	676633			374549	81977	1228	228140	182693	539492	44	21130
ECAP	M.SIAENS	6441			3139			3139		7853		-794
FIN	M.GOBLET	593535			168671	21736	937	55378	60772	168906	35	163267
GFCO	PELLEMANS P.	40714			30000	7011	1484	8703	35100	36146	19	6277
IAG	M.PROF.JUCKLER	136108			66535			25595		73240		20525
IAPS	P.LOWENTHAL	218728	100000	161416	188584	40501	3584	248838	105299	619117	38	-131413
PERF	M. MOITRIN ET PH.DE	10510			10510			9706		24287		-5856
PERS	PIERRE J.C.	50714			25000	10448		22667	22583	60212	46	-4032
PROD	J.T.LEHMANN	46930			17382	454	168	7969	1777	23479	25	9321
QANT	M.PROF.JUCKLER	1588051			597286	67008	3531	377142	158448	965797	42	207918
REG	J.DELCOURT	1848092			680876	150226	8028	560570	505567	1891082	29	100285
RETN	CRACCO ET.	190000			40085	2532		16207	6364	52410	39	53793
SCON	VAN DEN HOVE O.	27142			10000			4039		12834		5936
SOC	PRESVELOU CL.	66847			24628	1674	320	21909	8379	103172	19	2696
SPOL	J.BUCHMANN	7323										2695
SSOC	R.REZSOHAZY	52779			20012	723	359	12947	3628	49993	19	6478
TRA	M.MOITRIN ET R.LERO	77300			43479			20591		172667		-136
	TOTAL 0	9878999	205188	176416	4517341	759737	95681	3358182	2596065	10999830	29	357033
	TOTAL (12 MONTHS) 0					9116844	1148172		31152780			
	RECAPITULATIVE	10451624			9878999	759737	95681	3358182			29	357033
	BALANCE (3)+(4)-(6)	572625										
	BALANCE (6)+(4)-(9)	672605										

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